Application No. 10/016,913

AMENDMENTS TO THE CLAIMS

A detailed listing of all claims that are, or were, in the present application, irrespective of whether the claim(s) remains under examination in the application are presented below. The claims are presented in ascending order and each includes one status identifier. Those claims not cancelled or withdrawn but amended by the current amendment utilize the following notations for amendment: 1. deleted matter is shown by strikethrough for six or more characters and double brackets for five or less characters; and 2. added matter is shown by underlining.

1-2. (Cancelled)

3. (Currently Amended) [[The]] A method for detecting the gap of a liquid-crystal panel ~~as described in claim 1~~, the method comprising the steps of:

arranging the liquid-crystal panel so that a polarized incident light is incident almost parallel to the normal to the liquid-crystal panel and the reflected light from the liquid-crystal panel is received by a received light quantity detection device via an analyzer having a transmission axis almost perpendicular to the polarization direction of the incident light;

rotating the direction of polarization of the incident light with respect to the liquid-crystal panel and detecting the extinction angle at which the intensity of light detected by the received light quantity detection device reaches minimum; and

detecting the gap of the liquid-crystal panel based on the detected extinction angle,

wherein gap d of the liquid-crystal panel is detected by the following equations by using the detected extinction angle ϕ_{app}:

$$\tan 2\phi \text{ app} = \tan 2\left(\phi \text{ app} + \frac{\pi}{2}\right) = \phi \frac{\tan X}{X}$$

$$X=\sqrt{\phi^2+\beta^2} \quad \beta=\frac{\pi\Delta nd}{\lambda}$$

$$\Delta n=\frac{n_e \cdot n_o}{\sqrt{n_o{}^2+(n_e{}^2-n_o{}^2)\sin^2\theta}}-n_o$$

where λ is the wavelength of the incident light, ϕ is the twisting angle of the liquid-crystal panel, n_o is the refractive index of the liquid crystal material with respect to ordinary light, n_e is the refractive index of the liquid crystal material with respect to extraordinary light, Δn is the refractive index anisotropy of the liquid-crystal panel, and θ is the tilt angle of the liquid-crystal panel.

4. (Cancelled).

5. (Currently Amended) [[The]] A method for detecting the gap of a liquid-crystal panel ~~as described in claim 4~~, the method comprising the steps of:

arranging the liquid-crystal panel so that a polarized incident light falls almost parallel to the normal to the liquid-crystal panel and the reflected light from the liquid-crystal panel is received by a received light quantity detection device via an analyzer;

detecting a first output signal from the received light quantity detection device in a state in which the transmission axis of the analyzer is arranged so as to be almost parallel to the polarization direction of the incident light;

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detecting a second output signal from the received light quantity detection device in a state in which the transmission axis of the analyzer is arranged so as to be almost perpendicular to the polarization direction of the incident light; and

detecting the gap of the liquid-crystal panel based on the first and second output signals,

wherein gap d of the liquid-crystal panel is detected by the following equations by using the first output signal R_x and the second output signal R_y:

$$R_x = \cos^2\beta_{eff} + \cos^2 2(\phi_{app}+\alpha^{in})\sin^2\beta_{eff}$$

$$R_y = \sin^2 2(\phi_{app}+\alpha^{in})\sin^2\beta_{eff}$$

$$\cos\beta_{eff} = \cos^2 X + (\varphi^2 - \beta^2)\frac{\sin^2 X}{X^2}$$

$$\cos 2\varphi_{app} \cdot \sin\beta_{eff} = 2\beta\frac{\sin X \cdot \cos X}{X}$$

$$\sin 2\varphi_{app} \cdot \sin\beta_{eff} = 2\varphi\beta\frac{\sin^2 X}{X^2}$$

$$\beta_{eff} = \frac{2\pi \cdot \Delta neff \cdot d}{\lambda}$$

$$\tan 2\varphi_{app} = \varphi\frac{\tan X}{X}$$

$$X = \sqrt{\varphi^2+\beta^2} \qquad \beta = \frac{\pi\Delta n\, d}{\lambda}$$

$$\Delta n = \frac{n_e \cdot n_o}{\sqrt{n_o^2+(n_e^2 - n_o^2)\sin^2\theta}} - n_o$$

where λ is the wavelength of the incident light, φ is the twisting angle of the liquid-crystal panel, n_o is the refractive index of the liquid crystal material with respect to ordinary light, n_e is the refractive index of the liquid crystal material with respect to extraordinary light, Δn is the refractive index anisotropy of the liquid-crystal panel, θ is the tilt angle of the liquid-crystal

panel, and α^{in} is the angle between the polarization direction of the incident light and the orientation direction of liquid crystal molecules at the substrate on the incident light side.

6. (Currently Amended) [[The]] A method for detecting the gap of a liquid-crystal panel ~~as described in claim 4 further comprising a step of~~, the method comprising the steps of:

arranging the liquid-crystal panel so that a polarized incident light falls almost parallel to the normal to the liquid-crystal panel and the reflected light from the liquid-crystal panel is received by a received light quantity detection device via an analyzer;

detecting a first output signal from the received light quantity detection device in a state in which the transmission axis of the analyzer is arranged so as to be almost parallel to the polarization direction of the incident light;

detecting a second output signal from the received light quantity detection device in a state in which the transmission axis of the analyzer is arranged so as to be almost perpendicular to the polarization direction of the incident light; and

detecting the gap of the liquid-crystal panel based on the first and second output signals; and

detecting a third output signal from the received light quantity detection device in a state in which the transmission axis of the analyzer is located on a bisector of the direction almost parallel to the polarization direction of the incident light and the direction almost perpendicular thereto, and in the step of detecting the gap of the liquid-crystal panel, the gap of the liquid-crystal panel is detected based on the first, second, and third output signals.

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7. (Previously Presented) The method for detecting the gap of a liquid-crystal panel as described in claim 6, wherein gap d of the liquid-crystal panel is detected by the following equations by using the first output signal R_x, the second output signal R_y, and the third output signal R_{xy}:

$$R_{xy} = \frac{1}{2}[1 + \sin^2\beta_{eff} \cdot \sin 4(\varphi_{app} + \alpha^{in})]$$

$$R_x = \cos^2\beta_{eff} + \cos^2 2(\phi_{app} + \alpha^{in}) \cdot \sin^2\beta_{eff}$$

$$R_y = \sin^2 2(\phi_{app} + \alpha^{in}) \cdot \sin^2\beta_{eff}$$

$$\cos\beta_{eff} = \cos^2 X + (\varphi^2 - \beta^2)\frac{\sin^2 X}{X^2}$$

$$\cos 2\varphi_{app} \cdot \sin\beta_{eff} = 2\beta\frac{\sin X \cdot \cos X}{X}$$

$$\sin 2\varphi_{app} \cdot \sin\beta_{eff} = 2\varphi\beta\frac{\sin^2 X}{X^2}$$

$$\beta_{eff} = \frac{2\pi \cdot \Delta neff \cdot d}{\lambda}$$

$$\tan 2\varphi_{app} = \varphi\frac{\tan X}{X}$$

$$X = \sqrt{\varphi^2 + \beta^2} \qquad \beta = \frac{\pi\Delta n\, d}{\lambda}$$

$$\Delta n = \frac{n_e \cdot n_o}{\sqrt{n_o^2 + (n_e^2 - n_o^2)\sin^2\theta}} - n_o$$

where λ is the wavelength of the incident light, φ is the twisting angle of the liquid-crystal panel, n_o is the refractive index of the liquid crystal material with respect to ordinary light, n_e is the refractive index of the liquid crystal material with respect to extraordinary light, Δn is the refractive index anisotropy of the liquid-crystal panel, θ is the tilt angle of the liquid-crystal

panel, and α^{in} is the angle between the polarization direction of the incident light and the orientation direction of liquid crystal molecules at the substrate on the incident light side.

8-11. (Cancelled).

12. (Currently Amended) [[The]] A method for detecting the gap of a liquid-crystal panel ~~as described in claim 4 further comprising the steps of~~, the method comprising the steps of:

arranging the liquid-crystal panel so that a polarized incident light falls almost parallel to the normal to the liquid-crystal panel and the reflected light from the liquid-crystal panel is received by a received light quantity detection device via an analyzer;

detecting a first output signal from the received light quantity detection device in a state in which the transmission axis of the analyzer is arranged so as to be almost parallel to the polarization direction of the incident light;

detecting a second output signal from the received light quantity detection device in a state in which the transmission axis of the analyzer is arranged so as to be almost perpendicular to the polarization direction of the incident light; and

detecting the gap of the liquid-crystal panel based on the first and second output signals;

measuring a fourth output signal representing the noise light quantity, which contains the surface reflected light from the received light quantity detection device as the main component, in a state in which the transmission axis of the analyzer is arranged so as to be almost parallel to the polarization direction of the incident light; and

measuring a fifth output signal representing the noise light quantity, which contains the external light from the received light quantity detection device as the main component, in a state in which the transmission axis of the analyzer is disposed so as to be almost perpendicular to the polarization direction of the incident light, wherein the gap of the liquid-crystal panel is detected based on the first to fifth output signals.

13-23. (Cancelled).

24. (Currently Amended) [[The]] An apparatus for detecting the gap of a liquid-crystal panel ~~as described in claim 19~~, comprising:

a light emission apparatus for causing a polarized incident light to fall almost parallel to the normal to the liquid-crystal panel;

an analyzer disposed so as to receive the reflected light from the liquid-crystal panel;

a received light quantity detection device for receiving the light that passed the analyzer; and

a processing apparatus, wherein the processing apparatus detects the gap of the liquid-crystal panel based on a first output signal from the received light quantity detection device in a state in which the analyzer is disposed so that the transmission axis of the analyzer is almost parallel to the polarization direction of the incident light and a second output signal from the received light quantity detection device in a state in which the analyzer is disposed so that the transmission axis of the analyzer is almost perpendicular to the polarization direction of the incident light

wherein the processing apparatus detects the gap of the liquid-crystal panel based on the first output signal, the second output signal, a fourth output signal representing the noise light quantity, which contains the surface reflected light from the received light quantity detection device as the main component, in a state in which the transmission axis of the analyzer is disposed so as to be almost parallel to the polarization direction of the incident light, and a fifth output signal representing the noise light quantity, which contains the external light from the received light quantity detection device as the main component, in a state in which the transmission axis of the analyzer is disposed so as to be almost perpendicular to the polarization direction of the incident light.

25. (Cancelled).

26. (Original) An apparatus for detecting the gap of a liquid-crystal panel, comprising:

a light emission apparatus for causing a polarized incident light to fall almost parallel to the normal to the liquid-crystal panel;

an analyzer disposed so as to receive the reflected light from the liquid-crystal panel;

a received light quantity detection device for receiving the light that passed the analyzer; and

a processing apparatus, wherein the processing apparatus detects the gap of the liquid-crystal panel based on a first output signal from the received light quantity detection device in a state in which the analyzer is disposed so that the transmission axis of the analyzer is almost parallel to the polarization direction of the incident light, a second output signal from the

received light quantity detection device in a state in which the analyzer is disposed so that the transmission axis of the analyzer is almost perpendicular to the polarization direction of the incident light, and a third output signal from the received light quantity detection device in a state in which the analyzer is disposed so that the transmission axis of the analyzer is located on a bisector of the direction almost parallel to the polarization direction of the incident light and the direction almost perpendicular thereto.

27. (Original) The apparatus for detecting the gap of a liquid-crystal panel, as described in Claim 26, wherein the light emission apparatus comprises a polarizer.

28. (Original) The apparatus for detecting the gap of a liquid-crystal panel, as described in Claim 26, wherein the received light quantity detection device uses a surface-type imaging element.

29. (Original) The apparatus for detecting the gap of a liquid-crystal panel as described in Claim 26, wherein the light emission apparatus or the received light quantity detection device has a wavelength selection function.

Please add new claims 30-38 as follows:

30. (New) A method for detecting a gap of a liquid-crystal panel, the method comprising the steps of:

arranging the liquid-crystal panel so that a polarized incident light falls almost parallel to a normal to the liquid-crystal panel and a reflected light from the liquid-crystal panel is received by a received light quantity detection device via an analyzer;

detecting a first output signal I_x from the received light quantity detection device in a first state in which the transmission axis of the analyzer is arranged so as to be almost parallel to a polarization direction of the incident light; and

detecting a second output signal I_y from the received light quantity detection device in a second state in which a transmission axis of the analyzer is arranged so as to be almost perpendicular to the polarization direction of the incident light,

wherein the gap of the liquid crystal panel is detected based on reflection factors R_x and R_y of the liquid-crystal panel respectively in the first state in which the transmission axis of the analyzer is arranged so as to be almost parallel to the polarization direction of the incident light, and in the second state in which the transmission axis of the analyzer is arranged so as to be almost perpendicular thereto, the reflection factors R_x and R_y being calculated by using the following equations:

$$I_x = I_0 \cdot R_x + I_{cx}$$

$$I_y = I_0 \cdot R_y + I_{cy}$$

where I_0 is a quantity of incident light onto the liquid-crystal panel, I_{cx} and I_{cy} are noise light quantities respectively in the first state in which the transmission axis of the analyzer is arranged so as to be almost parallel to the polarization direction of the incident light, and in the second state in which the transmission axis of the analyzer is arranged so as to be almost

perpendicular thereto, and the reflection factors R_x and R_y are functions of the gap and satisfy the relationship [$R_x + R_y = 1$].

31. (New) The method for detecting the gap of a liquid-crystal panel of claim 30, wherein in the step of detecting the first output signal I_x and in the step of detecting the second output signal I_y, the detection is conducted in at least two different rotation positions obtained by rotating about an axis almost parallel to a direction of incidence of the incident light on the liquid-crystal panel as a center and the gap of the liquid-crystal panel is detected based on the first and the second output signals detected in each of the rotation positions.

32. (New) The method for detecting the gap of a liquid-crystal panel of claim 31, wherein angles differ by no less than 5°.

33. (New) The method for detecting the gap of a liquid-crystal panel of claim 30, wherein a half mirror is provided for reflecting a source light from a light source and directing the source light toward the liquid-crystal panel, and for transmitting the reflected light from the liquid-crystal panel, and wherein in the step of detecting the gap of the liquid-crystal panel, the gap of the liquid-crystal panel is detected by the first and the second output signals corrected based on a transmissivity of the half-mirror.

34. (New) A method for detecting a gap of a liquid-crystal panel, this method comprising the steps of:

directing a polarized incident light almost parallel to the normal to the liquid-crystal panel;

directing reflected light from the liquid-crystal panel into a polarization beam splitter and separating a first reflected light with a first polarization direction almost parallel to the incident light polarization direction and a second reflected light with a second polarization direction almost perpendicular to the incident light polarization direction; and

detecting a quantity I_x of first reflected light with the first polarization direction almost parallel to the incident light polarization direction with a first received light quantity detection device and detecting the quantity I_y of second reflected light with a second polarization direction almost perpendicular to the incident light polarization direction with a second received light quantity detection device,

wherein the gap of the liquid crystal panel is detected based on reflection factors R_x and R_y of the liquid-crystal panel respectively in a first state in which a transmission axis of an analyzer is arranged so as to be almost parallel to the incident light polarization direction, and in a second state in which the transmission axis of the analyzer is arranged so as to be almost perpendicular thereto, the reflection factors R_x and R_y being calculated by using the following equations:

$$I_x = I_0 \cdot R_x + I_{cx}$$

$$I_y = I_0 \cdot R_y + I_{cy}$$

where I_0 is a quantity of incident light onto the liquid-crystal panel, I_{cx} and I_{cy} are noise light quantities respectively in the first state in which the transmission axis of the analyzer is arranged so as to be almost parallel to the polarization direction of the incident light, and in the

second state in which the transmission axis of the analyzer is arranged so as to be almost perpendicular thereto, and the reflection factors R_x and R_y are functions of the gap and satisfy the relationship $[R_x + R_y = 1]$.

35. (New) An apparatus for detecting a gap of a liquid-crystal panel, comprising:

a light emission apparatus for causing a polarized incident light to fall almost parallel to a normal to the liquid-crystal panel;

an analyzer disposed so as to receive a reflected light from the liquid-crystal panel;

a received light quantity detection device for receiving the light that passed the analyzer; and

a processing apparatus,

wherein the processing apparatus calculates reflection factors R_x and R_y of the liquid-crystal panel respectively in a first state in which a transmission axis of the analyzer is arranged so as to be almost parallel to the polarization direction of the incident light, and in a second state in which the transmission axis of the analyzer is arranged so as to be almost perpendicular thereto, by using a first output signal I_x from the received light quantity detection device in the first state in which the transmission axis of the analyzer is arranged so as to be almost parallel to the polarization direction of the incident light and a second output signal I_y from the received light quantity detection device in the second state in which the transmission axis of the analyzer is arranged so as to be almost perpendicular thereto, the reflection factors R_x and R_y being calculated by using the following equations:

$$I_x = I_0 \cdot R_x + I_{cx}$$

$$I_y = I_0 \cdot R_y + I_{cy}$$

where I_0 is a quantity of incident light onto the liquid-crystal panel, I_{cx} and I_{cy} are noise light quantities respectively in the first state in which the transmission axis of the analyzer is arranged so as to be almost parallel to the polarization direction of the incident light, and in the second state in which the transmission axis of the analyzer is arranged so as to be almost perpendicular thereto, and the reflection factors R_x and R_y are functions of the gap and satisfy the relationship $[R_x + R_y = 1]$, and

wherein the processing apparatus detects the gap of the liquid crystal panel based on the calculated reflection factors R_x and R_y.

36. (New) The apparatus for detecting the gap of a liquid-crystal panel of claim 35, wherein the liquid-crystal panel rotates about an axis almost parallel to the direction of incidence of the incident light as a center.

37. (New) The apparatus for detecting the gap of a liquid-crystal panel of claim 35, wherein the received light quantity detection device comprises a surface-type imaging element.

38. (New) An apparatus for detecting a gap of a liquid-crystal panel, comprising:

a light emission apparatus for causing a polarized incident light to fall almost parallel to a normal to the liquid-crystal panel;

a polarization beam splitter disposed so as to receive reflected light from the liquid-crystal panel and separating a first reflected light having a first polarization direction almost parallel to an incident light polarization direction of the incident light and second reflected light having a second polarization direction almost perpendicular to the incident light polarization direction from the reflected light;

a first received light quantity detection device disposed so as to receive the first reflected light having the first polarization direction almost parallel to the incident light polarization direction, the first reflected light being received from the polarization beam splitter;

a second received light quantity detection device disposed so as to receive the second reflected light having the second polarization direction almost perpendicular to the incident polarization direction, the second reflected light being received from the polarization beam splitter; and

a processing apparatus,

wherein the processing apparatus calculates reflection factors R_x and R_y of the liquid-crystal panel respectively in a first state in which a transmission axis of an analyzer is arranged so as to be almost parallel to the incident light polarization direction, and in a second state in which the transmission axis of the analyzer is arranged so as to be almost perpendicular thereto, by using an output signal I_x from the first received light quantity detection device and an output signal I_y from the second received light quantity detection device, the reflection factors R_x and R_y being calculated by using the following equations:

$$I_x = I_0 \cdot R_x + I_{cx}$$

$$I_y = I_0 \cdot R_y + I_{cy}$$

where I_0 is a quantity of incident light onto the liquid-crystal panel, I_{cx} and I_{cy} are noise light quantities respectively in the state in which the transmission axis of the analyzer is arranged so as to be almost parallel to the polarization direction of the incident light, and in the state in which the transmission axis of the analyzer is arranged so as to be almost perpendicular thereto, and the reflection factors R_x and R_y are functions of the gap and satisfy the relationship $[R_x + R_y = 1]$, and

wherein the processing apparatus detects the gap of the liquid crystal panel based on the calculated reflection factors R_x and R_y.